APPENDIX I
TOXICOLOGICAL PROFILES

ACIDS

Acids (pH < 7) are generally noted for their ability to burn skin and mucous membranes. Effects are more severe at very low pH; near the neutral 7, effects are typically negligible. Strong acids can burn and corrode the skin. When present in the air, acids can irritate the respiratory tract.

ACROLEIN

Acrolein is used as an herbicide and slimicide, and in the synthesis of many chemicals (Sittig, 1991). Acrolein is a highly toxic irritant to the skin, eyes, and respiratory tract, and can cause pulmonary edema after high-level inhalation exposure (Sittig, 1991; Lewis, 1992). Acrolein is classified as a Group C (possible) human carcinogen by USEPA.

ACRYLONITRILE

Acrylonitrile, also known as vinyl cyanide, is used in the manufacture of synthetic materials and as a pesticide (Sittig, 1991).

Acrylonitrile may be absorbed through the skin as well as via the oral and inhalation routes. Toxic effects are similar to those of cyanide poisoning. Reddening and blistering of the skin, dizziness, cyanosis, and convulsions may occur. Target organs include the central nervous system, cardiovascular system, liver, kidneys, and skin (Sittig, 1991).

Acrylonitrile is classified as a Group B1 (probable) human carcinogen by USEPA, based on lung cancer in industrial workers and brain cancer in rats.

ALUMINUM

Aluminum is a common, virtually ubiquitous element. This metal has been used in smelting, refining, electrical, aircraft, automotive, jewelry, petroleum processing, and rubber industries (Sittig, 1985). Aluminum foil is widely used in packaging.

Aluminum is not generally noted for toxicity. Some aluminum salts have been associated with skin and respiratory irritation. Inhalation of aluminum powder has been reported to cause pulmonary fibrosis. Some studies have suggested a link between aluminum exposure and Alzheimer's disease. (Sax, 1989; Sittig, 1985)

Aluminum has not been classified as a carcinogen by USEPA.

ANTIMONY

Antimony has been used in mining, smelting, refining, and alloy abrasive manufacture. Antimony has also been used in ammunition, batteries, pigments, plasticizers, glass, enamels, pottery, pharmaceuticals, and explosives (Sittig, 1985).

Antimony compounds can cause skin irritation. Acute oral ingestion of antimony can produce extreme irritation of the gastrointestinal tract, and in extreme cases, circulatory or respiratory failure. Chronic oral toxicity may be associated with dry throat, nausea, and anorexia. Other target organs include the liver and kidney. Antimony has not been classified as a carcinogen.

ARSENIC

Arsenic has been used by the agricultural, pigment, glass, and metal smelting industries. Arsenic is a ubiquitous metalloid element. Acute ingestion of arsenic can be associated with damage to mucous membranes including irritation, vesicle formation, and sloughing. Arsenic can also be associated with sensory loss in the peripheral nervous system and anemia. Liver injury is characteristic of chronic exposure. Effects of arsenic on the skin can include hyperpigmentation, hyperkeratosis, and skin cancer. (Doull et al, 1986)

USEPA classifies arsenic in drinking water as a Group A known oral human carcinogen.

BARIUM

Barium has been used in metal alloys. Barium compounds have also been used in the manufacture of rubber, paints, glass, paper, and linoleum. Barium compounds can be found in valves, X-ray diagnostics, and rodenticides (Sittig, 1985). Barium is relatively abundant in nature (Doull et al, 1986).

Some barium compounds are insoluble and are not absorbed by the gastrointestinal tract. However, ingestion of soluble barium compounds can affect the muscles, especially smooth muscles. Symptoms of such toxixity include gastroenteritis, muscle paralysis, and central nervous system effects. In severe toxicity, cardiac arrest can result. Barium is not classified as a carcinogen by USEPA.

BENZENE

Benzene is an aromatic hydrocarbon. It is associated with gasoline and has been used as a solvent in many industries, including the printing, plastics, and rubber industries.

Exposure to benzene may be associated with effects on the central nervous system (headache, dizziness), respiratory system (irritation), blood (aplastic anemia, anemia, leukemia), and skin (dermatitis) (Sittig, 1985). Gastrointestinal irritation has also been reported.

EPA has classified benzene as a Group A known human carcinogen. This is based on an increased incidence of leukemia in exposed workers and neoplasia in rats.

BERYLLIUM

Beryllium is used in alloys as well as X-ray and nuclear applications. The major source of beryllium exposure of the general population is from the combustion of coal and oil. (Doull et al, 1986)

Adverse effects can include respiratory effects (after inhalation exposure) or contact dermatitis. Other target organs include the liver, spleen, and heart (Sittig, 1985). Beryllium is classified by USEPA as a Group B2 probable human carcinogen via the oral and inhalation routes.

1,3-BUTADIENE

1,3-Butadiene has been most widely used in rubber manufacturing, but its uses in other industries such as plastics and resins are growing (Sittig, 1991). 1,3-Butadiene may act as a central nervous system depressant (causing narcotic effects), an asphyxiant (causing suffocation), and as an irritant (causing skin burns). It is classified as a Group B2 (probable) human carcinogen by the USEPA.

CADMIUM

Major sources of environmental cadmium contamination include sewage sludge and emissions from smelting. Cadmium has also been used in plating, pigments, and batteries. As an environmental contaminant, it is virtually ubiquitous.

Acute cadmium toxicity can be associated with gastrointestinal distress. Inhalation of cadmium can produce chemical pneumonitis and pulmonary edema. The principal effects of chronic exposure include kidney disease and effects on the cardiovascular and skeletal systems. (Doull et al, 1986)

USEPA classifies cadmium compounds as Group B1 probable human carcinogens via inhalation exposure.

CARBON TETRACHLORIDE

Carbon tetrachloride is a common solvent that has been used extensively in the dry cleaning industry (Sittig, 1985).

Carbon tetrachloride can be irritating to the skin and eyes. Carbon tetrachloride also depresses the central nervous system, and symptoms such as dizziness, headache, and loss of coordination may occur. Other symptoms may include nausea and vomiting (Sittig, 1985). Chronic exposures have been shown to cause liver and kidney damage. Alcohol is reported to act synergistically with carbon tetrachloride.

EPA has classified carbon tetrachloride as a Group B2 probable human carcinogen.

CHLORDANE

Chlordane is an insecticide that has been extensively used for termite control, but it has been banned in the United States. Chlordane affects the nervous system, and toxic effects can include ataxia, tremors, and convulsions. Liver toxicity may also be associated with chronic exposure. Chlordane is a lipophilic, persistent compound that, like DDT, can bioconcentrate significantly. Chlordane is often detected in conjunction with heptachlor; heptachlor can be a component of technical grade chlordane. Chlordane is classified by USEPA as a Group B2 probable human carcinogen (Sittig, 1985; Sax, 1989).

CHLOROFORM

Chloroform has been used as an anesthetic, although this use has been discontinued. Chloroform has been used as a solvent by a variety of industries. Chloroform is a common contaminant of public water supplies where it is formed by the interaction of chlorine and naturally occurring organic compounds (Sittig, 1985).

Chloroform can affect the liver, heart, and nervous system. The gastrointestinal system can also be affected. Symptoms of exposure can include dizziness, nausea, and skin irritation. Chloroform is classified a Group B2 probable human carcinogen by EPA.

CHROMIUM

Two forms of chromium, the hexavalent (Cr^{6+}) and trivalent (Cr^{3+}) forms, are considered to have the greatest biological significance. Trivalent is the more common form, but hexavalent compounds have greater industrial importance. Chromium compounds are associated with the chrome plating and metal finishing industries, textile plants, tanneries, and wood preservatives.

Hexavalent chromium is more toxic and mobile than trivalent chromium. Effects of chromium exposure include dermatitis and acute renal tubular necrosis, skin irritation and dermatitis. Trivalent compounds are considerably less toxic and are neither irritating nor corrosive. Inhalation exposure to chromium has been associated with respiratory carcinomas. (Doull et al, 1986)

Hexavalent chromium is considered to be a Group A known human carcinogen by inhalation, according to USEPA.

COAL TAR (CREOSOTE)

Coal tar compounds are derived from the carbonization of bituminous coal. Such emissions can occur from coke ovens, foundries, metal industries, etc. (Sittig, 1991). In studying the toxic effects of these chemicals, attention has primarily been focused on their cancer-causing potential. USEPA classifies coke oven emissions as a Group A (known) human carcinogen, and creosote as a Group B1 (probable, includes some evidence in humans) human carcinogen.

COPPER

Copper is a common and essential element. It has been used in the electrical industry and in piping, alloys, pesticides, catalysts, paints, and electroplating (Sittig, 1985).

Copper sulfate has been used as an emetic, and ingestion of excessive amounts of copper salts can produce gastorintestinal distress. Copper poisoning can produce hemolytic anemia. Dermal contact with copper may be associated with dermatitis. (Doull et al, 1986)

Copper has not been classified as a carcinogen by USEPA.

CROTONALDEHYDE

Crotonaldehyde has been used in resin and rubber manufacturing and has varied uses as a solvent. It is similar to acrolein (q.v.), though slightly less toxic. Irritant effects, gastrointestinal distress, and respiratory effects have been noted (Sittig, 1991). Crotonaldehyde is classified as a Group C (possible) human carcinogen by USEPA.

DDT, DDD AND DDE

4,4'-DDT is an insecticide that has been banned in the United States since 1972. 4,4'-DDT and its metabolites, 4,4'-DDD and 4,4'-DDE, are toxicants with long-term persistence in soil and water. Their high lipophilicity and low water solubility result in concentrated accumulation in the fat of wildlife and humans (Sittig, 1985). Thinning of eagle and osprey eggshells led to population declines for those birds (Doull et al, 1986).

Because of the persistence and dispersion of DDT compounds, they are therefore widespread environmental contaminants. Toxic effects to humans include convulsions, vomiting, and skin irritation. The target organs are the central nervous system, liver, kidneys, skin, and peripheral nervous system (Sittig, 1985). Experimental ingestion of 1.5 g of 4,4'-DDT resulted in discomfort, moderate neurological changes, and vomiting (Sax, 1989).

4,4'-DDT, 4,4'-DDD, and 4,4'-DDE are classified as oral Group B2 probable human carcinogens. 4,4'-DDT is also classified as an inhalation Group B2 carcinogen.

DIELDRIN

Dieldrin is a chlorinated hydrocarbon insecticide that is currently banned in the United States. It was used to control corn and citrus pests (Sittig, 1985).

Dieldrin has low volatility and low water solubility, which contribute to its persistence, and has a high affinity for fat, which results in a tendency to bioaccumulate. Dieldrin can affect the central nervous system, liver, kidneys, and skin. Symptoms can include dizziness, nausea, convulsions, and coma (Sittig, 1985).

Dieldrin is classified by USEPA as a Group B2 probable human carcinogen via the oral and inhalation routes.

2,3,7,8-TCDD, DIOXINS, AND FURANS

Chlorinated dioxins and furans are typically evaluated in terms of their congeners that are chlorinated in the 2,3,7,8-positions. 2,3,7,8-Tetrachloro-p-dibenzodioxin (2,3,7,8-TCDD) is the best known. These chemicals are inadvertent contaminants in the manufacturing process of chlorinated phenols, and may be found in trace amounts in pesticides. For this reason, trace amounts of dioxins are widespread in the environment (Sittig, 1991).

Chlorinated dioxins and furans can affect the skin (notably with a distinctive rash called chloracne), nervous system, liver, pancreas, and reproductive system. These compounds are extremely persistent, difficult to break down, and tend to bioaccumulate in living organisms (Sittig, 1991).

USEPA classifies 2,3,7,8-TCDD as a Group B2 (probable human) carcinogen.

ETHYLENE

Ethylene has many industrial uses in manufacturing. It has been used as a fruit ripener, and as an anesthetic (Sittig, 1991).

Toxic effects of ethylene include "freezing burns" of the skin, depression of the central nervous system, and inflammation of the kidney. The liver is also reported to be a target organ (Sittig, 1991).

ETHYLENE GLYCOL

Ethylene glycol is used as a solvent and a chemical intermediate. It is also used in heat exchangers, and perhaps its best-known use is as an antifreeze (Sittig, 1991).

Ethylene glycol is a mild irritant. Ingestion of this chemical has produced nausea and vomiting, depression of the central nervous system, and kidney failure as a delayed effect (Sittig, 1991).

ETHYLENE OXIDE

Ethylene oxide is used in the plastics industry, as a fumigant, and as a sterilizing agent. High-level exposure can produce respiratory system effects such as dyspnea, pneumonia, and pulmonary edema. Other target organs include the central nervous system and liver. Nausea, vomiting, cardiac arrhythmias, and irritant effects have also been reported (Sittig, 1991).

HEPTACHLOR, HEPTACHLOR EPOXIDE

Heptachlor is an insecticide closely related to chlordane. It has been banned in the United States except for external, subsurface application to dwellings for termite control (Sax, 1992). Heptachlor epoxide is a degradation product of heptachlor that also acts as a pesticide (Hawley, 1981).

Heptachlor is a persistent organochlorine pesticide, like DDT. Acute symptoms of toxicity can involve tremors, convulsions, kidney damate, and respiratory collapse. In man, a dose of 1 to 3 g can cause serious symptoms (Sax, 1992).

Both heptachlor and heptachlor epoxide are classified as Group B2 (probable human) carcinogens by USEPA via the oral and inhalation routes.

FLUORIDES

Fluorides are used in many industries, including the chemical industry. Uses range from fluoridation of drinking water to application as a pesticide (Sittig, 1991).

Fluoride toxicity typically manifests itself through nausea, vomiting, and effects on the bones and teeth. Such effects are not expected from the low levels used in drinking water. When inhaled, fluorides can irritate the respiratory tract (Sittig, 1991).

FORMALDEHYDE

Formaldehyde has been used in many industries. Its uses include as a fungicide, disinfectant, and preservative (Sittig, 1991).

Formaldehyde can cause respiratory irritation, pneumonia, and pulmonary edema at high levels. Nausea, vomiting and diarrhea, nephritis, and liver toxicity have also been reported. It is possible for allergies to formaldehyde to develop (Sittig, 1991).

Formaldehyde is classified by USEPA as a Group B1 (probable) human carcinogen.

GASOLINE

Gasoline is a highly flammable solvent. It is commonly used as a fuel. The composition may vary, but common components include benzene compounds (q.v.) and alkanes (Sittig, 1991).

Gasoline may cuase respiratory irritation, drowsiness, nausea, and numbness following inhalation. The component hexane has been associated with nerve damage, and benzene has been associated with hematopoietic effects such as anemia. Tetraethyl lead (q.v.) has also been a component of some gasoline formulas. The liver is another target organ for gasoline (Sittig, 1991).

HYDROGEN CHLORIDE

This chemical has a wide variety of uses, both as hydrogen chloride and in the form of aqueous solutions (hydrochloric or muriatic acid). Hydrochloric acid is also found as a digestive agent in the gastrointestinal tract. The most notable toxic effect is its ability to burn and corrode tissue. In the air, hydrogen chloride can cause respiratory irritation and pulmonary edema. Via the oral route, effects such as nausea and kidney inflammation are possible (Sittig, 1991).

MANGANESE

Manganese is used in the manufacture of dry cell batteries, paints, dyes, and in the chemical and glass and ceramics industries. Manganese is an essential nutrient in in food; the average human intake is reported to be approximately 10 mg/day (Sittig, 1985).

Previous reports of neurotoxicity from manganese were generally reported from high-level occupational exposure to dust and fumes. More recent studies have focused on exposures to drinking water, with subtle neurologic effects being reported after chronic consumption of high concentrations of manganese in water (Sittig, 1985; USEPA, 1994c).

Manganese is not classified as a carcinogen by USEPA.

MERCURY

Mercury has historically been linked to mining, smelting, paper pulp, electrical, chemical, pharmaceutical, and pesticide industries. Inorganic mercury is used in metal plating, tanning, feltmaking, taxidermy, and photography. Mercury may also be emitted from burning coal and natural gas and refining petroleum products.

Inhalation of mercury vapor can cause excitability, tremors, and gingivitis; upon acute exposure, corrosive bronchitis may occur. Ingestion of inorganic mercury compounds has resulted in corrosion of the gastrointestinal tract and renal failure (severe acute exposure, often seen with accidental or suicidal ingestioon of mercuric salts). Vasodilation and rashes have been associated with exposure to mercurous compounds. The major clinical features of organic mercury poisoning are paresthesia, ataxia, dysarthria, and deafness, resulting from neurologic damage. (Doull et al, 1986)

USEPA classifies mercury and its compounds as Group D, not classifiable as to carcinogenicity.

2-METHOXYETHANOL

2-Methoxyethanol is an ethylene glycol ether. It is used as a solvent in resin and paint manufacturing and as a constituent of soaps and cleaners (Sittig, 1991).

2-Mehtoxyethanol is a mild irritant both to the skin and respiratory tract. Ingestion of this chemical can affect the brain, liver, and kidney. Anemia is another reported effect (Sittig, 1991).

METHYLENE CHLORIDE (DICHLOROMETHANE)

Methylene chloride, also known as dichloromethane, is a volatile solvent and common labofatory contaminant. Like many volatile solvents, methylene chloride can affect the nervous system, especially after inhalation exposure. Potential effects include dizziness, numbness, eye and skin irritation, and cardiac effects.

Methylene chloride is classified by the EPA as a Group B2 (probable human) carcinogen via the oral and inhalation routes of exposure.

MIREX

Mirex is an organochlorine insecticide that is especially effective against fire ants. It has also been used as a fire retardant in plastics (Sittig, 1991).

Like other organochlorine pesticides, mirex can affect the skin (irritation), gastrointestinal system, nervous system, liver, and reproductive system. Organochlorine pesticides are persistent in the environment, tending to accumulate in fatty tissues (Sittig, 1991).

USEPA has classified mirex as a Group B2 (probable human) carcinogen.

NICKEL

Nickel is a metal that has been associated with ore refining, stainless, steel, electroplating, jewelry, plastics, batteries, enamels, coal oils, and a variety of other industries.

Nickel, a skin sensitizer, can cause dermatitis. The kidney and circulatory system may also be potential target organs. Nickel has not been classified as a carcinogen by USEPA.

t-NONACHLOR

t-Nonachlor is the major constituent of technical chlordane and technical heptachlor (q.v.).

PENTACHLOROANISOLE

Pentachloroanisole is a chlorinated hydrocarbon pesticide. It also occurs as a metabolite of the pesticides pentachlorophenol, pentachloronitrobenzene, and hexachlorobenzene. Reproductive effects have been reported in experimental studies (Lewis, 1992).

POLYCHLORINATED BIPHENYLS (AROCLORS)

Polychlorinated biphenyls (PCBs) have been used widely as insulators in transformers and capacitors. Other uses have included carbonless duplicating paper, plasticizers, adhesives, and hydraulic fluids. PCBs may be contaminants of waste oils.

Dermal contact with PCBs can result in chloracne, a form of severe dermatitis. Effects upon the liver can also be significant, involving jaundice, edema, and nausea. Target organs include the skin, eyes, and liver (Sittig, 1985). PCBs are also noted for their extreme tendency to bioaccumulate in fat tissue (Versar, 1979).

USEPA classifies PCBs as Group B2 (probable human) carcinogens, based on hepatocellular carcinomas in rats and mice (Aroclor 1260) and limited evidence of liver cancer in humans.

POLYCYLIC AROMATIC HYDROCARBONS

Polycyclic aromatic hydrocarbons (PAHs), also called polynuclear aromatic hydrocarbons, are compounds that consist of annelated aromatic rings. They are found in coal, tar, tobacco smoke, and petroleum, and occur as products of the combustion of organic material (Doull et al, 1986). PAHs can be formed in any hydrocarbon combustion process and may be released from oil spills (Sittig, 1985). This group of compounds includes phenanthrene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[a]pyrene (q.v.), indeno[1,2,3-c,d]pyrene, dibenz[a,h]anthracene, benzo[g,h,i]perylene, naphthalene, acenaphthylene, acenaphthene, dibenzofuran, fluorene, anthracene, benzo[k]fluoranthene, and carbazole.

Naphthalene is an irritant that can cause dermatitis, toxic effects on the red blood cells, liver, kidneys, and central nervous system. Damage to the lenses of the eyes has also been reported.

Benzo[a]pyrene, benz[a]anthracene, benzo[b]fluoranthene, indeno[1,2,3-c,d]pyrene, dibenz[a,h]anthracene, benzo[g,h,i]perylene, benzo[k]fluoranthene, and carbazole have been classified by USEPA as Group B2 probable human carcinogens.

BENZO[A]PYRENE

Benzo[a]pyrene is a polycyclic aromatic hydrocarbon (PAH) that is found in coal tar, oil, asphalt, and other petroleum products. It can also form from the incomplete combustion of organic material.

Dermal irritation upon contact with high concentrations of PAHs has been reported. Benzo[a]pyrene has produced tumors in all species tested by both the oral and dermal route of application (Sittig, 1985). USEPA classifies benzo[a]pyrene as a Group B2 probable human carcinogen. The toxicity of PAHs is often expressed in terms of equivalents to benzo[a]pyrene.

PROPYLENE

Propylene is a component of gasoline and is used in resin and alcohol manufacturing, among other industrial uses. Its primary effect in the air is as an asphyxiant, causing displacement of oxygen. Contact with the pure liquid can produce a "frostbite" effect. Target organs also include the heart and liver (Sittig, 1991).

SELENIUM

Selenium is used as a pigment in paints, dyes, and glass. It is also used in the rubber, insecticide, and photographic industries, and is an additive in anti-dandruff shampoos.

Elemental selenium is relatively nontoxic. However, compounds such as selenium dioxide and selenium oxychloride can be irritating to the eyes, mucous membranes, and respiratory tract. Symptoms of selenium exposure include gastrointestinal and central nervous system effects. Target organs include the upper respiratory system, eyes, skin, liver, kidneys, and blood (Sittig, 1985).

Selenium is classified as USEPA's Group D, not classifiable as to carcinogenicity.

SILVER

Silver is used in the manufacture of silverware, jewelry, scientific instruments, photographic films, plates, and paper, and mirrors. The main adverse effect of silver exposure derives from the deposition of silver particles in the skin, which causes a pigmentation called argyria. Silver nitrate can be an irritant. Silver tends to accumulate in the body and is not readily excreted (Sittig, 1985).

TETRACHLOROETHENE

Tetrachloroethene (PCE), also known as perchloroethylene, is a commonly used solvent in the dry cleaning, degreasing, and textile industries. It is also used as an intermediate in the manufacture of organic chemicals (Sittig, 1985).

Irritation of the skin can occur after dermal exposure. High-level inhalation exposure can cause respiratory and eye irritation. Other effects include CNS depression and liver damage (Sax, 1989).

EPA ECAO classifies PCE as a Group B2 probable human carcinogen, although this is not considered Agency-wide consensus at this time.

VANADIUM

Vanadium is a ubiquitous element. It has been associated with petroleum refining, steel industries, pigments, glass manufacturing, photography, and insecticides.

Toxicity is usually reported after industrial inhalation exposure, which can be associated with bronchitis, bronchopneumonia, irritation, gastrointestinal distress, heart palpitations, and kidney damage. Ingestion of vanadium has been associated with gastrointestinal disturbances and renal and nervous system effects. Experimental studies suggest the liver, adrenals, and bone marrow as target organs. (Doull et al, 1986)

Vanadium has not been classified as a carcinogen by USEPA.

VINYL CHLORIDE

Vinyl chloride is a volatile organic compound used in the manufacture of polyvinyl chloride and other resins. It is also used as a chemical intermediate and a solvent (Sittig, 1985). Vinyl chloride can be found environmentally as a breakdown product of tetrachloroethene, trichloroethene, 1,1-dichloroethene, and 1,2-dichloroethene.

Vinyl chloride can cause skin irritation and CNS depression. Chronic exposure may cause hepatic damage (Doull, 1986). Vinyl chloride is classified by EPA as a Group A (known) human carcinogen, and has been specifically associated with hemangiosarcoma of the liver.

ZINC

Zinc is a common element and an essential metal not usually noted for toxicity. Intake occurs mainly from the diet, and the average American daily intake is reported to be approximately 12 to 15 g. About 20 to 30 percent of ingested zinc is absorbed (Doull et al, 1986).

Some zinc salts can be irritants. Gastrointestinal symptoms have sometimes been reported after ingestion of high zinc concentrations. Metal fume fever can result from inhalation of zinc fumes (Doull et al, 1986). Zinc is not classified as a carcinogen by USEPA.